U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-271 553

American Lake, Pierce County, Washington

National Eutrophication Survey, Las Vegas, Nev

Prepared for

Environmental Monitoring and Support Lab, Las Vegas, Nev

Jul 77

PB 271 553

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22151

☆ U.S.G.P.O. 1975-640

Report
on
American Lake
Pierce County
Washington
EPA Region X
Working Paper No. 864

With the cooperation of the
Washington Department of Ecology
and the
Washington National Guard
July, 1977

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1 REPORT NO.	2 RECIPIENT'S ACCESSION NO.
4 TITLE AND SUBTITLE: Report on American Lake, Pierce County, Washington	5 REPORT DATE: Prepared July 1977
7 AUTHOR(S): Anonymous (National Eutrophication Survey Staff)	8 PERFORMING ORGANIZATION REPORT NO.: Working Paper No. 864
9 PERFORMING ORGANIZATION NAME AND ADDRESS: National Eutrophication Survey U.S. Environmental Protection Agency P.O. Box 15027 Las Vegas, NV 89114	10 PROGRAM ELEMENT NO. 11 CONTRACT/GRANT NO.
12 SPONSORING AGENCY NAME AND ADDRESS: Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460	13 TYPE OF REPORT AND PERIOD COVERED: Final - 1976 14 SPONSORING AGENCY CODE

15 SUPPLEMENTARY NOTES: Prepared in cooperation with the U.S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, Eutrophication Survey Branch, Corvallis, OR 97330

16 ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17 KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Eutrophication Lakes Nutrients Phosphorus Nitrogen Loading		05B 05C

18 DISTRIBUTION STATEMENT: Release unlimited

19 SECURITY CLASS (This Report) — 21 NO. OF PAGES: 40

20 SECURITY CLASS (This Page) — 22 PRICE

EPA-414 (9-73)

REPORT ON AMERICAN LAKE

PIERCE COUNTY, WASHINGTON

EPA REGION X

by

National Eutrophication Survey

Water and Land Quality Branch
Monitoring Operations Division
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Special Studies Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 864

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

July 1977

CONTENTS

	Page
Foreword	ii
List of Washington Study Lakes	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	4
III. Lake Water Quality Summary	6
IV. Nutrient Loadings	12
V. Literature Reviewed	16
VI. Appendices	17

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Washington Department of Ecology for professional involvement, to the Washington National Guard for conducting the tributary sampling phase of the Survey, and to those Washington wastewater treatment plant operators who provided effluent samples and flow data.

Ms. Barbara Blau, Lake Restoration Program, and the staff of the Washington Department of Ecology, Lake Restoration Program, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

Major General Howard S. McGee, Adjutant General of Washington, and Project Officer Colonel Clinton C. Johnson, who directed the volunteer efforts of the Washington National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF WASHINGTON

LAKE NAME	COUNTY
American Lake	Pierce
Banks Lake	Grant, Douglas
Chelan Lake	Chelan
Diamond Lake	Pend Oreille
Green Lake	King
Keechelus Lake	Kittitas
Mayfield Lake	Lewis
Medical Lake	Spokane
Moses Lake	Grant
Ozette Lake	Clallam
Sammamish Lake	King
Lake Whatcom	Whatcom
Lower Granite Reservoir	Garfield, Whatcom

AMERICAN LAKE
Tributary Sampling Site
Lake Sampling Site
Scale
Vicinity Map
LAKE IOLA
PARKLAND
FORT LEWIS
Muck Creek
Clover Creek
Ponders Creek
Spanaway Creek
Morey Creek
Flett Creek
Garfield Creek
Parkland Creek
Brookdale Creek
Mount Rainier
Clarkmoore Dairy
Pacific Ave
Park Ave
Yakima Ave
Pine Ave
Spanaway Loop Rd
Military Rd
Golf Course
Golf Course
Golf Course

REPORT ON AMERICAN LAKE, WASHINGTON

STORET NO. 5301

I. CONCLUSIONS

A. Trophic Condition:*

Survey data indicate that American Lake is mesotrophic. Chlorophyll a values in the lake ranged from 0.3 µg/l in April to 19.8 µg/l in October with a mean of 4.8 µg/l. Potentials for primary production as measured by algal assay control yields were moderate to high. Lake transparency was good. Of the 13 Washington lakes sampled in 1975, 3 had higher median total phosphorus levels (0.027 mg/l), 6 had higher median inorganic nitrogen levels (0.105 mg/l), and 7 had higher median orthophosphorus values (0.007 mg/l) than American Lake.

Survey limnologists did not report any problem algal blooms or aquatic macrophytes in the lake during the sampling year. However, Ketelle and Uttormark (1971) report the occurrence of nuisance algal blooms in the lake for which regular chemical treatments are applied.

*See Appendix E.

B. Rate-Limiting Nutrient:

The algal assay results indicate that American Lake was primarily limited by phosphorus during the spring sampling (04/01/75) and nitrogen during the fall sampling (10/29/75). The lake data suggest phosphorus limitation in the spring and nitrogen limitation during summer and fall.

C. Nutrient Controllability:

1. Point sources -

There were no known municipal or industrial point sources impacting American Lake during the sampling year. Septic tanks, however, were estimated to contribute 7.3% of the total phosphorus loading to the lake.

The calculated annual phosphorus loading of 0.10 g $P/m^2/yr$ is less than that proposed by Vollenweider (1975) as a "eutrophic" loading but greater than his proposed "oligotrophic" loading. Collings (1973) reports that nutrient accumulation in the lake is reduced because of flushing action from surface- and groundwater discharges. However, the lake receives heavy recreational use (Bortleson, et al., 1976) and possibly substantial runoff from surrounding urban areas, so should be watched carefully for any future indications of overenrichment.

2. Nonpoint sources -

Murray Creek contributed 35.4% of the total phosphorus input to American Lake during the sampling year. Ungaged tributaries were estimated to have contributed 40.6% of the total phosphorus load.

There is no natural outlet to American Lake, although a culvert for flood protection has been installed which periodically overflows into Sequalitchew Creek (Bortleson, et al., 1976; Collings, 1973). Since information on the nutrient outflow from the lake is not available, the net annual nutrient accumulation in the lake cannot be determined in this report. Additional sampling is needed to determine the true nutrient budget for American Lake before recommendations in controllability can be proposed.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake morphometry data were provided by Walcott (1965). Tributary flow data were provided by the Washington District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake morphometry:

1. Surface area: 4.70 km^2.
2. Mean depth: 15.4 meters.
3. Maximum depth: 27.4 meters.
4. Volume: 72,279 x 10^6 m^3.
5. Mean hydraulic retention time: 13,943 days (38.2 yrs).

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage Area (km^2)	Mean flow (m^3/sec)
B-1 Murray Creek	28.2	0.16
Minor tributaries and immediate drainage -	32.9	0.00
Totals	61.1	0.16
2. Outlet - A-1 Sequalitchew Creek	65.8	0.96

C. Precipitation:

1. Year of sampling: 109.1 cm.
2. Mean annual 93.7 cm.

III. LAKE WATER QUALITY SUMMARY

American Lake was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll *a* analysis and phytoplankton identification and enumeration. During the first and last visits, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 7.9 meters at Station 01, 18.3 meters at Station 02, and 27.4 meters at Station 03. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll *a* determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/01/75	1. Fragilaria	430
	2. Chroomonas	373
	3. Melosira	373
	4. Cryptomonas	155
	5. Stephanodiscus	93
	Other genera	124
	Total	1,553
07/17/75	1. Cyclotella	529
	2. Chroomonas	611
	3. Melosira	91
	4. Oocystis	73
	5. Ankistrodesmus	55
	Other genera	220
	Total	1,479
10/29/75	1. Aphanocapsa	550
	2. Fragilaria	321
	3. Chroomonas	263
	4. Asterionella	175
	5. Cryptomonas	117
	Other genera	351
	Total	1,782

8. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
04/01/75	01	0.1
	02	0.3
	03	0.3
07/17/75	01	3.0
	02	4.5
	03	6.8
10/29/75	01	19.0
	02	2.6
	03	5.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered and nutrient spiked -

a. 04/01/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.004	0.093	0.7
0.05 P	0.055	0.093	4.7
0.05 P + 1.0 N	0.055	1.093	22.7
1.00 N	0.005	1.093	0.6

b. 10/29/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.040	0.080	5.3
0.05 P	0.090	0.080	5.1
0.05 P + 1.0 N	0.090	1.080	33.3
1.00 N	0.040	1.080	21.3

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential for primary productivity of American Lake was moderate during spring sampling (04/01/75) and high during the autumn sampling (10/29/75). In the April assay a significant increase in yield over that of the control occurred when phosphorus alone was added, indicating phosphorus limitation. In the October sample, the addition of nitrogen alone produced a significant increase in yield beyond that of the control, indicating nitrogen limitation at that time. In both samples the maximum increase in yield beyond that of the control was produced by the addition of nitrogen and phosphorus simultaneously.

The mean inorganic nitrogen to orthophosphorus (N/P) ratios in the lake data were approximately 22/1, 7/1, and 5/1 in the spring, summer, and fall respectively, suggesting phosphorus limitation in the spring and nitrogen limitation in the summer and fall (a mean N/P ratio of 14/1 or greater generally reflects phosphorus limitation).

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Washington National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of March when two samples were collected. Sampling was begun in September 1974, and was completed in July 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Washington District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in kg/km^2/year in Murray Creek, at Station B-1, and multiplying the means by the ZZ area in km^2.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
B-1 Murray Creek	170	35.4
b. Minor tributaries and immediate drainage (nonpoint load) -	195	40.6
c. Known municipal STP's - None		
d. Septic tanks*	35	7.3
e. Known industrial - None		
f. Direct precipitation** -	80	16.7
Totals	480	100.0

2. Output - A-1 Sequalitchew Creek - Unknown

*Estimate based on 125 lakeshore residences.
**Estimated (See NES Working Paper No. 175).

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
B-1 Murray Creek	3,580	25.2
b. Minor tributaries and immediate drainage (nonpoint load) -	4,180	29.5
c. Known municipal STP's - None		
d. Septic tanks* -	1,330	9.4
e. Known industrial - None		
f. Direct precipitation** -	5,075	35.7
Totals	14,165	100.0

2. Output - A-1 Sequalitchew Creek - Unknown

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2.yr	kg N/km^2/yr
Murray Creek	6	127

*Estimate based on 125 lakeshore residences.
**Estimated (See NHS Working Paper No. 175).

E. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A "mesotrophic" loading would be considered one between "eutrophic" and "oligotrophic".

Note that Vollenweider's model may not apply to lakes with short hydraulic retention times or in which light penetration is severely restricted by high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading ($g/m^2/yr$)
Estimated loading for American Lake	0.10
Vollenweider's "eutrophic" loading	0.13
Vollenweider's "oligotrophic" loading	0.06

V. LITERATURE REVIEWED

Bortleson, G.C., M.P. Dion, J.B. McConnell, and L.M. Nelson. 1976. Reconnaissance Data on Lakes in Washington, Volume 3. (Kitsap, Mason and Pierce Counties). Washington State Department of Ecology Water Supply Bulletin 43, Volume 3.

Collings, M.R. 1973. Data on Selected Lakes in Washington, Part I. USGS in cooperation with the Washington State Department of Ecology, Tacoma, Washington.

Ketelle, Martha J. and Uttormark, Paul D. 1971. Problem Lakes in the United States. U.S. Environmental Protection Agency Project #16010EHR. University of Wisconsin, Madison, Wisconsin.

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R.A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

Walcott, E.E. 1965. Lakes of Washington, Volume I. Washington Division of Water Resources, Water Supply Bulletin, 14 and 15.

VI. APPENDICES

APPENDIX A
CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B
TRIBUTARY FLOW DATA

[redacted]

APPENDIX C
PHYSICAL AND CHEMICAL DATA

APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[redacted]

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1975

STATE OF WASHINGTON

Mean or median values for six of the key parameters evaluated in establishing the trophic conditions of Washington lakes sampled are presented to allow direct comparison of the ranking, by parameter, of each lake relative to the others. Median total phosphorus, median inorganic nitrogen and median dissolved orthophosphorus levels are expressed in mg/l. Chlorophyll a values are expressed in ug/l. To maintain consistent rank order with the preceding parameters, the mean Secchi disc depth, in inches, is subtracted from 500. Similarly, minimum dissolved oxygen values are subtracted from 15 to create table entries.

LAKE DATA TO BE USED IN RANKING

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SUB-MEAN VEC	MEAN CHLORA	25-MIN SD	MEDIAN SECC DEPTH
5301	[illegible] LAKE	0.027	0.195	343.107	4.822	15.880	0.887
5302	[illegible] LAKE	0.021	0.240	384.533	7.373	10.800	0.887
5303	[illegible] LAKE	0.005	0.370	111.000	0.405	0.400	0.887
5304	[illegible] LAKE	0.014	0.260	383.667	14.527	14.200	0.810
5305	[illegible] LAKE	0.027	0.350	425.880	2.983	18.400	0.809
5306	[illegible] LAKE	0.007	0.240	298.250	1.439	9.200	0.957
5307	[illegible] LAKE	0.014	0.190	402.000	4.250	10.600	0.897
5308	[illegible] LAKE	0.275	0.205	491.714	37.425	15.000	0.346
5309	[illegible] LAKE	0.115	0.150	403.683	25.060	14.600	0.730
5310	[illegible] LAKE	0.010	0.110	403.333	1.325	7.200	0.809
5311	[illegible] LAKE	0.025	0.210	374.000	7.290	14.600	0.884
5312	[illegible] LAKE	0.009	0.329	298.000	3.430	12.400	0.696
5313	[illegible] RESERVOIR	0.033	0.150	479.500	4.875	7.200	0.320

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SUM-MEAN SEC	MEAN CHLORA	25-MEAN SD	MEDIAN SECCHI DEPTH P
9301	[illegible] LAKE	29 (35	50 (60	67 (80	50 (60	4 (4	58 (70
9302	[illegible] LAKE	42 (50	100 (120	58 (70	25 (30	46 (50	71 (85
9303	[illegible] LAKE	108 (120	67 (80	100 (120	100 (120	100 (120	92 (110
9304	[illegible] LAKE	67 (75	75 (90	75 (90	17 (20	33 (40	25 (30
9305	[illegible] LAKE	29 (35	83 (100	17 (20	75 (90	67 (75	46 (55
9306	[illegible] LAKE	92 (110	92 (110	92 (110	83 (100	75 (90	100 (120
9307	[illegible] LAKE	67 (75	58 (70	33 (40	58 (70	42 (50	75 (85
9308	[illegible] LAKE	8 (10	8 (10	42 (50	8 (10	4 (10	8 (10
9309	[illegible] LAKE	8 (10	29 (30	8 (10	8 (10	21 (25	8 (10
9310	[illegible] LAKE	75 (90	42 (50	25 (30	92 (110	87 (100	33 (40
9311	[illegible] LAKE	58 (60	17 (20	58 (60	33 (40	21 (25	92 (100
9312	[illegible] LAKE	83 (100	8 (10	83 (100	67 (80	46 (50	46 (50
9313	LOWER [illegible] RESERVOIR	17 (20	29 (30	8 (10	42 (50	87 (100	17 (20